

Next steps toward understanding human habitation of space: environmental impacts and mechanisms.

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Entry into low earth orbit and beyond causes profound shifts in environmental conditions that have the potential to influence human productivity, long term health, and even survival. We now have evidence that microgravity, radiation and/or confinement in space can lead to demonstrably detrimental changes in the cardiovascular (e.g. vessel function, orthostatic intolerance), musculoskeletal (muscle atrophy, bone loss) and nervous (eye, neurovestibular) systems of astronauts. Because of both the limited number of astronauts who have flown (especially females) and the high degree of individual variability in the human population, important unanswered questions about responses to the space environment remain: What are the sex differences with respect to specific physiological systems? Are the responses age-dependent and/or reversible after return to Earth? Do observed detrimental changes that resemble accelerated aging progress continuously over time or plateau? What are the mechanisms of the biological responses? Answering these important questions certainly demands a multi-pronged approach, and the study of multicellular model organisms (such as rodents and flies) already has provided opportunities for exploring those questions in some detail. Recent long duration spaceflight experiments with rodents show that mice in space provide a mammalian model that uniquely combines the influence of reduced gravitational loading with increased physical activity. In addition, multiple investigators have shown that ground-based models that simulate aspects of spaceflight (including rodent hindlimb unloading to mimic weightlessness and exposure to ionizing radiation), cause various transient and persistent detrimental consequences in multiple physiological systems. In general, we have found that adverse skeletal effects of simulated weightlessness and space radiation when combined, can be quantitatively, if not qualitatively, different from the influence of each environmental factor alone implying at least some shared underlying mechanisms. Thus, both groundbased and spaceflight research utilizing model organisms provide the opportunity to better understand environmental factors and biological mechanisms that contribute to human health and survival in space.

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